Helen A. M. Wyatt

June 12 1863

Notes

from her Cousin

on her 11th birthday

To

Robert G. M. Wyatt.

with his sister's love.

March 6th 1864.

Smelaars lith.

1. Desmidium Swartzii
2. Micrasterias denticulata
3. Euastrum oblongum.
4. Cosmarium margaritiferum.
5. Xanthidium armatum.
6. Arthrodesmus convergens.
7. Staurastrum cuspidatum.
8. Closterium acerosum.
9. Closterium Dianae
10. Closterium setaceum.
11. Echasterum pennatum.
12. Pediastrum Napoleonis
13. Scenedesmus quadricaudata.
14. Navicula viridis.
15. Navicula amphisbæna.
16. Navicula acus.
17. Bacillaria vulgaris
18. Bacillaria cuneata.

CURIOSITIES

OF THE

MICROSCOPE,

OR

Illustrations of the Minute Parts of Creation,

ADAPTED TO THE

CAPACITY OF THE YOUNG,

WITH

COLORED ILLUSTRATIONS.

BY

REV. JOS. H. WYTHES, M. D.,

AUTHOR OF THE "MICROSCOPIST," ETC.,

"EVERY GRAIN OF SAND IS AN IMMENSITY,—EVERY LEAF A WORLD."

Lavater.

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1852.

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TO

MY BROTHER,

Rev. Wm. W. WYTHES, M. D.,

IN TOKEN

OF THE MUTUAL PLEASURE RECEIVED,

IN THE

INVESTIGATION OF NATURAL PHENOMENA,

THESE

Curiosities of the Microscope,

ARE AFFECTIONATELY

INSCRIBED.

PREFACE.

There is no subject so amazing as that revealed by the Microscope, or so well calculated to lead the thoughts to the contemplation of the attributes of that Being, with whom there is nothing great nor small; by whom every object is

> "compassed beneath his spacious wing,
> Each fed and guided by his powerful arm."

Yet seldom is the mind of the young directed to this subject.

From the lack of books pertaining to microscopic science, the author indulges the hope

that this little work may form an agreeable introduction to the study of this part of nature, for any who may be interested therein. To such, the simplicity of the style will be no objection.

Just such particulars have been noticed in the present volume as promised to afford most interest and instruction to that class of readers for which it is more specially designed. A gradation has been aimed at, however, both in style and matter, from the simplest descriptions of common objects, to a delineation of the most marvellous organizms known to natural science.

CONTENTS.

CHAPTER I.

THE MICROSCOPE EXPLAINED.

William and Thomas Peale had been spending some weeks at the house of their uncle, Mr. Simons. He was much attached to his nephews, and took pleasure in talking with, and instructing them. He was a naturalist; that is, one fond of studying the works of nature, and therefore tried to direct their thoughts to the wonderful works of God displayed in Creation. Sometimes he would walk with them into the fields, and show them many curious objects which they would

not otherwise have noticed. At other times they would examine many strange minerals, fossils and shells, which were in their uncle's cabinet. On clear evenings, they would look through a telescope at the Moon, or the planets Jupiter and Saturn, which shone brightly in the sky at that season of the year.

One afternoon, after their uncle's return from his counting house, he brought into the sitting room a mahogany box, and took out of it a strange looking instrument made of brass. The boys looked on with a good deal of interest, and at length William asked him the name of the instrument. Mr. Simons replied that it was called a Microscope, and that it answered the same purpose as a common

magnifying glass, only it made objects appear a great deal larger.

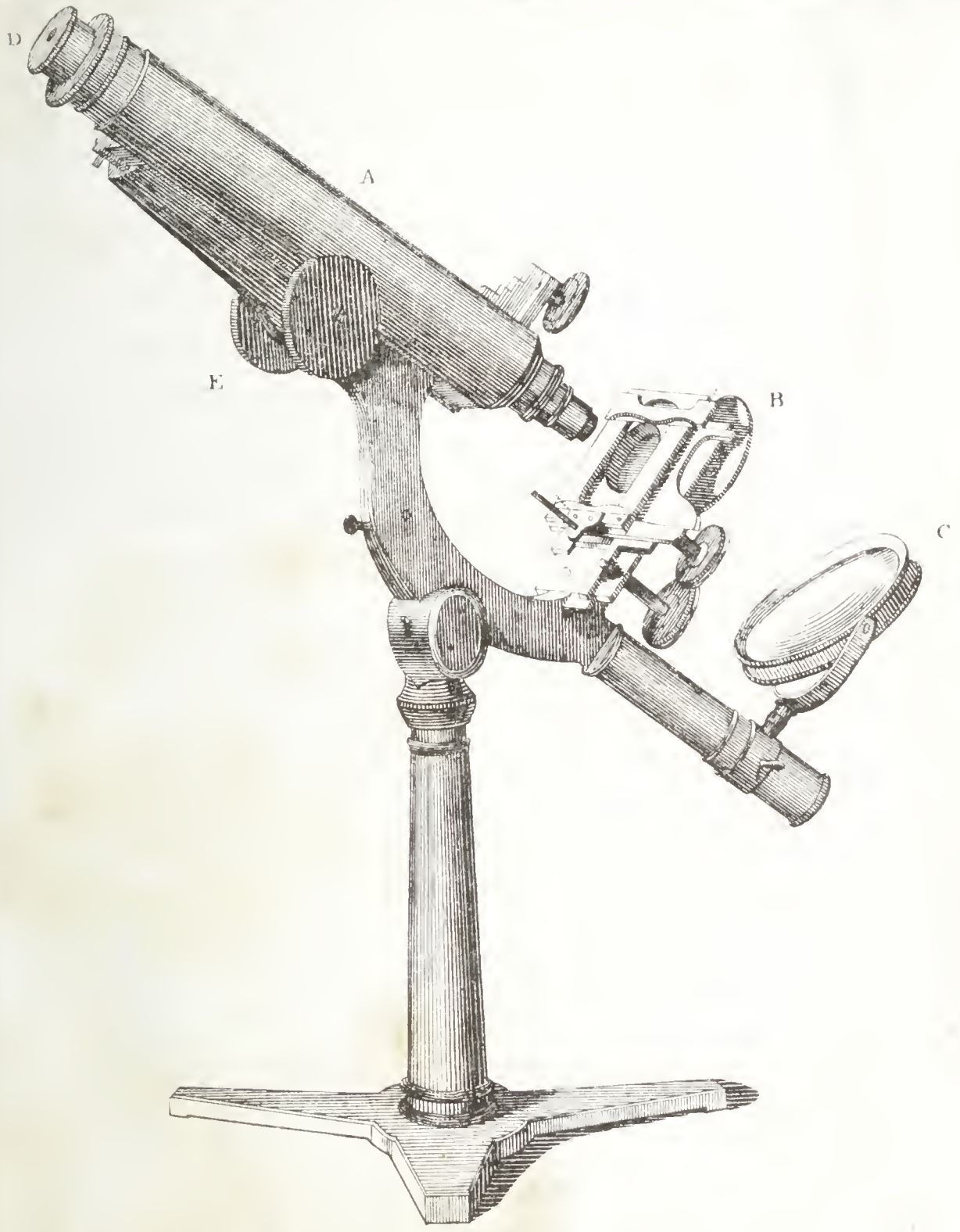
As some of my young readers are not acquainted with the principles on which a Microscope is constructed, I will try to explain them in a simple and familiar manner.

I suppose you have all seen a common magnifying glass, or burning glass, (which some of you may have used as a toy in the sunshine to set fire to small pieces of paper, etc.: If you hold such a glass at a certain distance from a small object, (say an inch or two) and look through it, the object will appear larger than it really is, and you will see it more distinctly. The smaller the glass is, the nearer you must bring it to the object and the more it will magnify. Some very pow-

erful glasses are so small as not to be larger than the head of a pin. Such glasses are very inconvenient to use, therefore when we wish to magnify an object a great deal, we make use of two or three glasses so arranged as to answer the same purpose.

Within the last ten years the Microscope has been very much improved, and has added many things to our knowledge respecting the works of Creation.

Microscopes are not all made alike, although the principle is the same in all of them. Here is a picture of one (*Plate I.*) which will give you some idea of its various parts. The glasses which magnify the object are placed in the tube, represented near the letter A. The stage, marked B is for holding the object,



Sinclairs 2th

THE MICROSCOPE.

and at C is a looking glass, or mirror, for the purpose of directing the light up through the instrument. When we wish to examine any small substance, we place it on the stage, look through the end of the tube marked D, and move the tube up and down by means of a rack-work at E.

Many instruments are much more complicated than that represented, and others are very simple, but all have the three parts mentioned above; viz, a mirror; a stage; and the magnifying or optical part of the microscope.

Microscopists usually speak of the magnifying power of their instruments in reference to the diameter of the object viewed; that is, the simple measure across; thus an instru-

ment is said to magnify fifty, one hundred, or three hundred diameters, as the case may be.

The size of objects is expressed usually in parts of an inch, as one-fiftieth, one-hundreth, or one-thousandth part of an inch. In order to ascertain the actual size, various modes are employed. The most simple is to place on the stage of the microscope a piece of glass which has fine lines ruled on it, perhaps an hundredth part of an inch apart, and comparing these divisions with a rule seen by the naked eye. In this way we may learn how much the microscope magnifies. Now if we compare the apparent size of an object on the stage, with the rule as before, and divide that apparent size by the magnifying power of the

instrument, we shall learn exactly how large it is. The piece of glass with the fine lines ruled on it, is called a *Micrometer*, which means an instrument to measure small things, as the word *Microscope* means an instrument to observe small things.

Now if we find by the Micrometer that the Microscope magnifies two hundred and fifty times, and a small object at which we are looking appears to be an inch in diameter, we know that it really is but the two hundred and fiftieth part of an inch in diameter.

We should feel very grateful to our heavenly Father that he has given us not only eyes to behold His wondrous works, but powers of mind by which we are en-

abled to extend the field of our observations to those objects which without such capacity would have been forever invisible.

CHAPTER II.

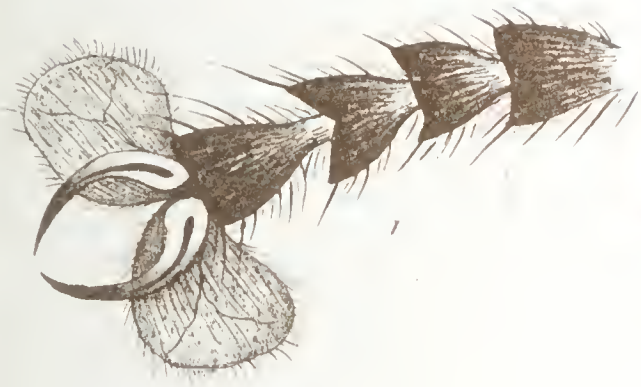
WHAT THE MICROSCOPE DOES.

"Does the Microscope only make objects appear much larger, uncle," said Thomas, "or can we see things which are invisible to the naked eye?"

"You shall see," answered Mr. Simons, "I have here the foot of a common house-fly which I will put in the instrument. Now you can look at it."

The boys looked into the Microscope, and saw the object; which appeared similar to this picture. (*Plate II. fig.* 1.)

"The joints in the fly's foot," said their uncle, "make it very flexible, and the two claws can lay hold of any object which may help it along. But the most remarkable parts are the pads or cushions which you see in this specimen at the side of each claw. It used to be supposed that by their aid the fly walks on smooth glass or on the ceiling, on the same principle with which you sometimes lift up a stone with a leathern sucker; but later and more careful observers have thought that a sort of glue comes out of the pores in the pads which enables him to walk on glass. This may be the reason the fly is so careful to clean his feet; for as in cold weather the glue would get hard, it would prevent him from walking at all; and the



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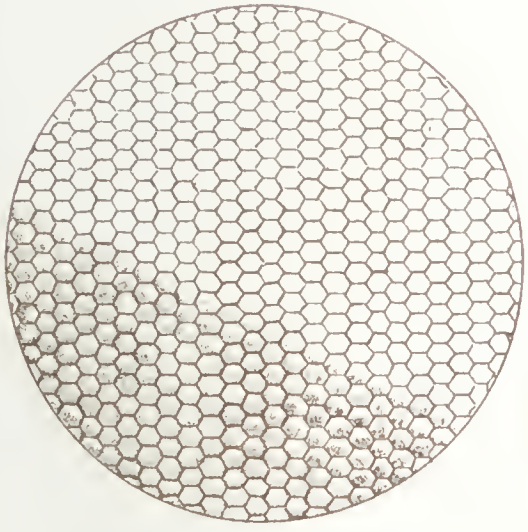


3

4

1. Foot of a fly 2 Spiders claw 3. Flys eye 4 Proboscis of a fly.

same effect would be produced if it were to remain on his feet too long. Now if you watch a fly, you will often see him brushing and nibbling away at his feet, no doubt with the intention of removing the hardened glue from the pads.

"The feet of insects are very differently formed, so as to suit their habits or modes of life.

"Here is a spider's foot, (*Plate II. fig.* 2.) and you will see that it is armed with terrible looking claws, fitted for seizing its prey. This view may remind you of the passage of Scripture which says, 'The spider taketh hold with her hands, and is in kings' palaces.'

"The limbs of some insects are exceedingly

consists of several layers. Beneath this is a broad portion which has the appearance of lace. This is the bark, whose vessels in this specimen are arranged in bundles of a round or oval shape. Within this, is the sap wood, or the newest portion of the wood; next, the woody part of the branch, and within all, at the smallest part of the section, the pith. The woody portion you observe marked with lines or rays of cellular tissue proceeding from the pith to the bark, and also with numerous dots or holes which are the spiral and sap vessels cut across. You may also distinguish three distinct rings in the wood, answering to each year's growth; so that you may thereby tell its age, which is little more than three years.

Section of Wood.

"A slice cut across a branch is not always sufficient to show its true character; sometimes we are obliged to cut a thin piece lengthwise, and another obliquely, if we would understand its construction

"Vegetable matter is organized, or arranged in three different forms, as cellular tissue, as woody fibre, or as tubular vessels.

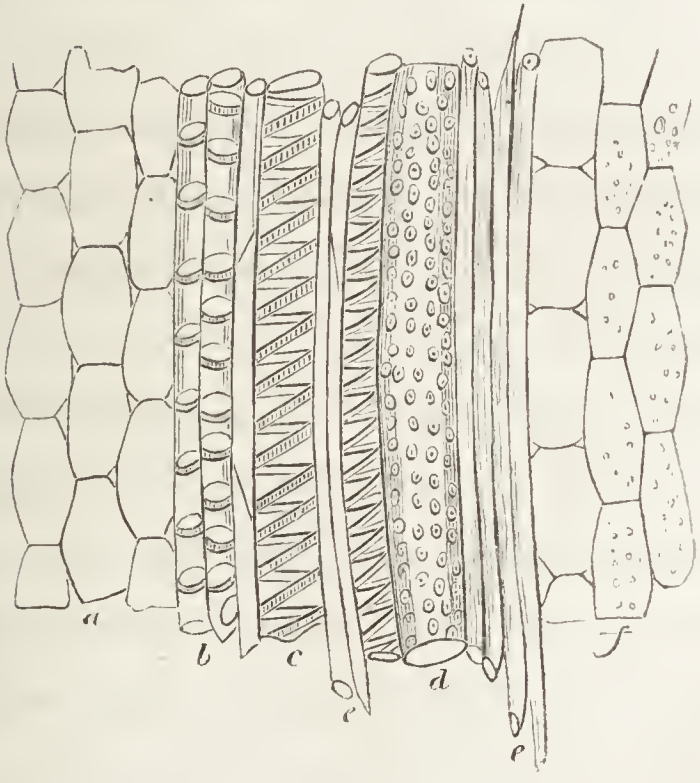
"If you can imagine a barrel or box full of eggs you will have the simplest idea of *cellular tissue;* each cell being distinct from the rest and being usually full of fluid substance. But the cells may be of different shapes, as round, oval, star-like, flat, or irregular.

"*Woody fibre* seems to be constituted by elongated cells, generally spindle shaped, which are so much longer than broad, that

they appear like so many threads or fibres. These fibres or elongated cells, are filled with a hard substance, by which they are fitted to give a firm and durable character to the vegetables in which they most abound. In the stems of herbs, and in the softer parts of other plants, as their leaves and flowers, a few woody fibres may be found giving support to the tubular vessels. In Pine and Fir trees, and others of a similar class, the woody fibres are beautifully marked or dotted at the sides, so that we can tell by the inspection of a very small piece of wood with the Microscope, whether it belongs to that tribe.

Tubular vessels run lengthwise through the plant, and generally serve for the conveyance of fluid nutriment. They are variously

constituted. Some of them are composed of a very delicate membrane kept on the stretch by a spiral fibre inside. These are called *spiral vessels*. Other vessels seem to be strengthened by fibrous rings at intervals.



These are *annular ducts* or vessels. Others again are porous or dotted on the sides and are called *dotted ducts*. In the preceding cut you will see an example of each of these vessels and tissues. It represents a longitudinal section of Italian reed:—*a*, is the cellular tissue of the pith; *b*, are annular ducts; *c*, are spiral vessels; *d*, is a dotted duct; *e*, are woody fibres; and *f*, is the cellular tissue of the integument or skin.

By this time tea was ready, and the examination of these curiosities was suspended until after family worship; for Mr. Simons never neglected this duty. The boys were much pleased with what they had seen; and thought a good deal about it. When their

uncle read the evening chapter from the Bible, their attention was directed to the passage in the 6th chapter of Matthew; "Behold the fowls of the air; for they sow not, neither do they reap, nor gather into barns; yet your heavenly Father feedeth them. Are ye not much better than they?" They had often read this passage themselves, yet it seemed now to have a meaning in it which had never occurred to them before; and they thought, Surely if our Heavenly Father careth for the little insects, he will care for us. Let us hope that they resolved to obey his blessed will.

CHAPTER III.

MORE CURIOSITIES.

In the evening, after they had assembled again, one of the boys caught a white moth which had been flying round the lamp while their uncle was preparing the instrument. The white dust came off the insect's wing upon his fingers, and his curiosity having been awakened with what he had seen in the afternoon, he asked his uncle how it would look in the Microscope.

"The dust on the wings and bodies of moths and butterflies, and some other in-

Scales of Butterflies Wings

sects," said Mr. Simons, "consists of small feathers or scales. I have some on this glass which I will exhibit to you. It is from a small butterfly called the *Pontia Brassica* (or cabbage butterfly.)

"There are other kinds also from several different insects, each species having scales peculiar to itself. (*Plate IV.*)

"The delicate markings on these scales sometimes require the very finest instruments in order to show them distinctly.

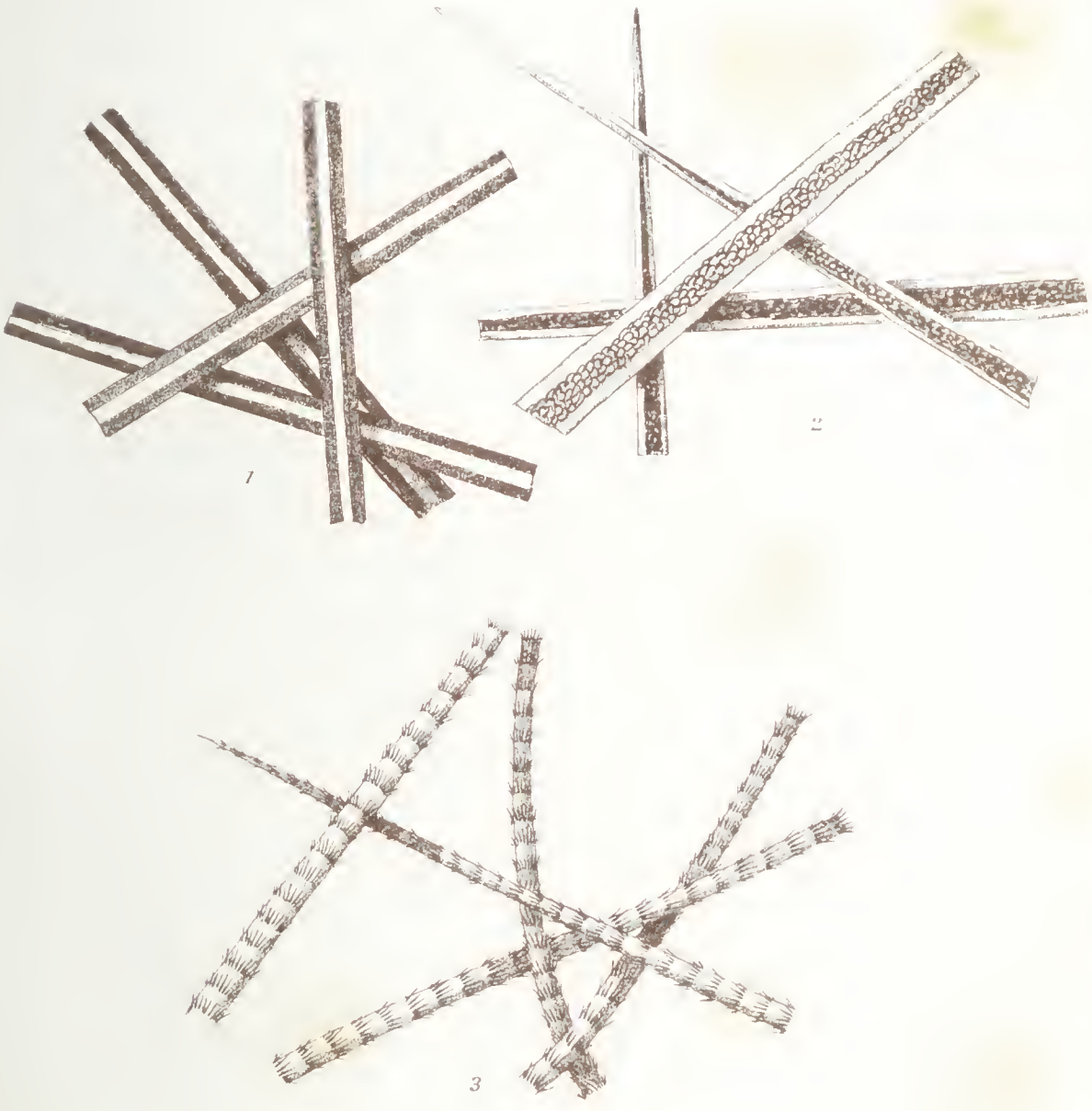
"I will now," continued their uncle, "exhibit to you several different sorts of hair. Here is some from my own head. (*Plate V. fig.* 1.) You perceive that it appears round, and smooth, and hollow. Very careful observations, however, have proved that

instead of being smooth, its surface is covered with scales.

"This next object is the hair of a Rabbit, the coloring matter of which is arranged in cells inside each hair. (*Plate V. fig.* 2.)

"The hair of a bat is also a very singular object, being surrounded with little tufts or whirls at certain regular distances as you may perceive. (*Plate V. fig.* 3.)

"In all these things, as well as in every thing else exhibited by the Microscope, we see how much care has been bestowed by the Great Creator on the smallest things in nature. Some people have thought so much of the starry worlds and their grandeur as to suppose that it is below the dignity of our Heavenly Father, (so to speak) to take notice



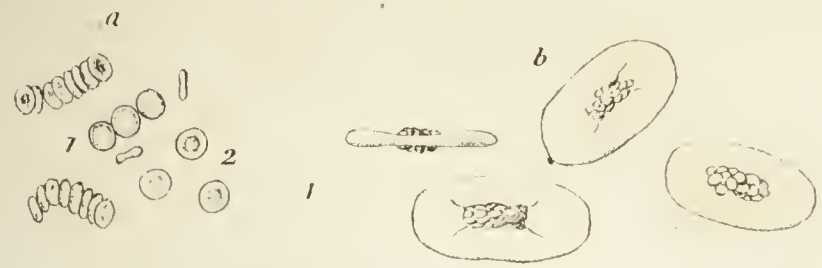
1 Human Hair 2 Hair of a Rabbit 3 Bat's Hair

of us. The discoveries of the Microscope will drive away such suppositions; for they show us that God's perfection is exhibited as fully in the small and even invisible parts of creation, as in the planets and suns which move and shine in the firmament. We must not measure God by ourselves. He is all-powerful in every place, as well as all-wise and pure. Nothing is too small for Him to notice; and nothing too large for his guidance and power.

"Upon this glass," continued Mr. Simons, "I have a drop of blood. I pricked my finger one day with a pin, and as I felt curious to look at the globules of blood, I placed a drop here and allowed it to dry." (*Plate VI. a, fig.* 1.)

"How very curious!" cried the two boys; "there is quite a multitude of small drops or globules, and each one seems to be flat, and marked with a ring in it."

"Blood," said their uncle, "is an object of much interest, when viewed by a high magnifying power. It is proven that the red color of the blood is entirely owing to these little globules, or cells, which float about like bladders, filled with a peculiar kind of fluid. In man and the higher animals these cells are round, and flat, and concave on each side; but in the cold-blooded animals, as frogs, lizards, and snakes, the globules are oblong, and much larger in size than the others. (*Plate VI. b, fig.* 1.) It has only been a little more than 200 years since it



2.

1 Human Blood Globules. 2 Circulation in the web of a frogs foot

was known that all the blood in the body is in constant motion, continually circulating through various tubes called blood-vessels to and from the heart; but if the Microscope had been much employed before that time, the discovery would have been made earlier, for with this instrument we can see the blood in actual motion, as I will show you."

Mr. Simons took from a jar a live frog, which he had provided for the purpose. He then put him in a wet muslin bag, leaving one foot out of the bag, and tied him up so that he could not struggle to get away. Then, after fastening the bag to a plate of brass which was prepared with a hole at one end, he stretched out the web of the foot over the hole in the brass and placed it under the

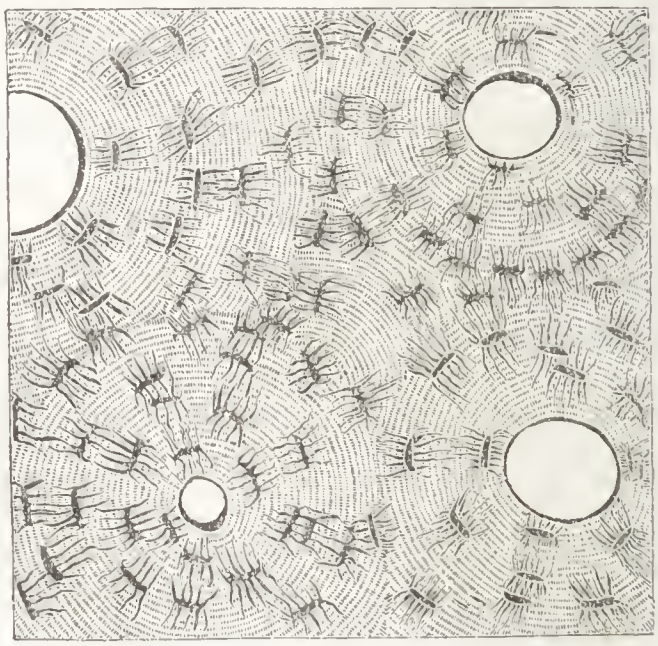
object glass of the Microscope. The boys looked in and beheld the particles of blood circulating with great rapidity through the blood-vessels. They saw the arteries propelling it in a direction from the heart toward the extremities. From these it was received by much smaller vessels, so small that they could only transmit a globule at a time. These vessels are called capillaries, and convey the blood to the veins, which return the blood to the heart, sending it in an opposite direction from the arteries. (*Plate VI. fig.* 2.)

"The smallest blood-vessels of the body, called capillaries," remarked Mr. Simons, "are arranged very differently in different parts, and when Anatomists would examine their peculiarities, they fill them with finely

ground paint, or some other colored substance, which enables us to see them more readily on account of their transparency. This is done by a process called injecting."

He then showed them how beautifully these vessels were arranged in folds around the inside of the pupil of the eye; also, the lace-like network of vessels in the lining membrane of the stomach; and the mode in which they were packed in around the branching air-tubes in the lungs, so that the blood might all be exposed to the enlivening action of the air when we breathe. Many other interesting specimens of this kind were exhibited, showing the power and wisdom of the Great Creator in the smallest portions of our bodily frame.

Mr. Simons then showed them a thin piece of bone, cut crosswise, so as to show the canals or vessels for transmitting blood through the bone for its growth and nourishment. (*Fig.* 2.) Around these vessels are arranged a number of dark spots of an irregular figure, generally oblong, communicating



with each other and with the canals by radiating lines. These dark spots are cells for holding the nutrient fluid of the bone, and the communicating lines are vessels.

The bone cells are of different form and size in different classes of animals, so that by examining a small piece of bone, we can tell whether it belonged to a beast, bird, reptile, or fish.

Now in very many rocks, found in different places on the earth, we obtain what are called fossil remains; that is, the bones of fishes birds and animals, the shells of shell-fish, and the leaves and stems of vegetables, altered by a gradual change into stone similar in kind to the rock in which the remains are found. Sometimes it is very difficult to

judge from the form of a fossil bone to what sort of animal it belonged; but with the aid of a Microscope, it may be very generally ascertained, even if we have but a very small piece, or chip of bone.

Thus, the Microscope not only unfolds the minuter parts of nature to our astonished gaze, exhibiting the marks of design and adaptation, as fully in those things which are hidden from our natural vision, as in those with which we are daily conversant; but it also transports our minds far back in the history of the world, and proves the general plan of creation to have been the same in olden time as now.

CHAPTER IV.

HOW INSECTS BREATHE.

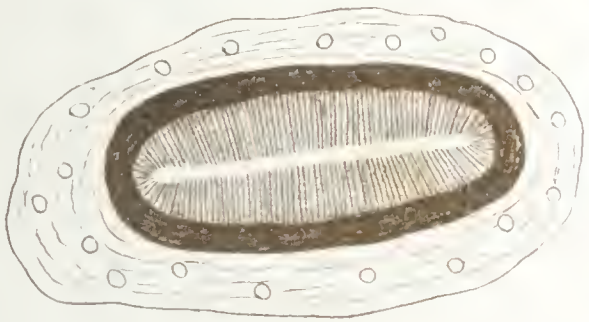
On a succeeding evening when they were assembled in the parlor, Mr. Simons told his nephews that he would explain to them, the curious manner in which insects breathe.

"Insects have no lungs," said Mr. Simons, "like man and other animals, nor have they gills like fishes, but they take in the air in a manner peculiar to themselves. Instead of breathing through the mouth, they receive and expel the air by means of a number of holes or spiracles placed along the sides of

the abdomen. In order to prevent particles of dust, etc., entering these spiracles when they breathe, the wise Creator has provided them with a species of net work. In the Microscope you will see one of these spiracles taken from a caterpillar. (*Plate VII. fig.* 1.)

"I will now show you one of a different construction, from a kind of water-beetle which you may sometimes have seen skimming along the surface of the water. It is called the *Dytiscus Marginalis.* (*Plate VII. fig.* 2.)

"These spiracles or breathing holes placed in the sides of the insect, communicate with two large tubes, one on each side which run along its entire length. These tubes, or



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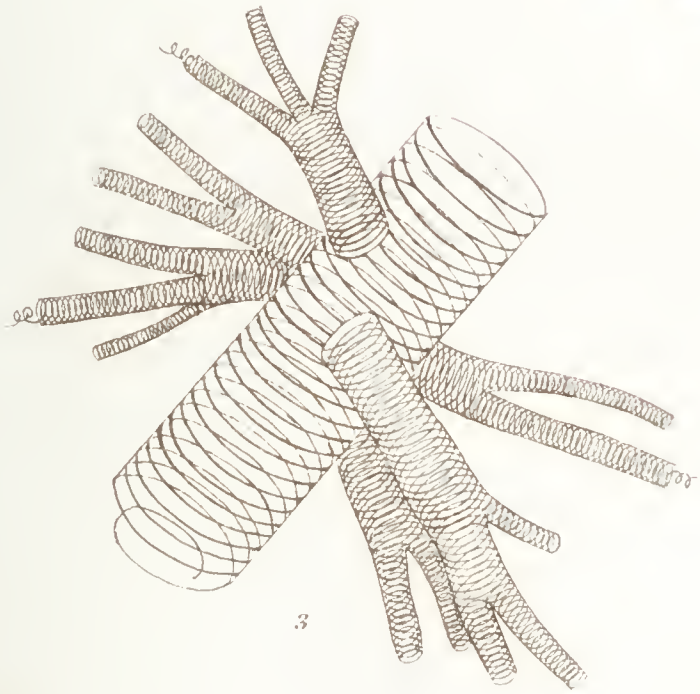


3

1. Spiracle of a Caterpillar 2. Spiracle of Dytiscus Marginalis
3 Trachea of an Insect

trachea, send off branches to every part of the creature, so that the air tubes in an insect are as much divided and subdivided as the blood-vessels in other animals. In order that these trachea or air-tubes may be as delicate and light as possible, and yet strong enough for the purpose intended, a very wise provision has been made. A strong spiral fibre is wound inside the delicate membrane which composes the tube. You may see it in this specimen under the Microscope. (*Plate VII. fig.* 3.)

"In insects that live in the water, these trachea, instead of being furnished with spiracles at the sides, have their breathing holes placed at or near the tail, so that the creature need only protrude his tail above the water

now and then in order to obtain a supply of air. This is especially the case with many aquatic larvæ."

"What are larvæ? uncle," asked William.

"Larvæ," replied Mr. Simons, "are insects at a certain stage of their growth or development. All insects pass through several changes before arriving at their perfect form. Do you not remember the different changes of the silk-worms you had last summer?"

"O yes!" said William. "A little caterpillar was hatched from the egg, which grew larger and ate a good many leaves, and then it spun a cocoon and changed into a chrysalis, from which it came out a beautiful moth which laid its eggs, and died!"

"I thought," said Thomas, "that these

changes only took place in butterflies and moths."

"That is a mistake," replied their uncle, "all insects pass through similar changes, though these changes may not be so clearly perceived as in the butterfly tribe. The first state after the egg is the larva state. The caterpillar therefore is the larva of the butterfly. Many insects in their larva condition live in the water. I suppose you may have seen in the rain cask, or in other places a great many curious looking animals wriggling about, and often coming to the top of the water, or rather protruding their tails above the water, to breathe. These are the larvæ of musquitoes. I will put a small one under the Microscope, so that you

may see it when magnified. (*Plate VIII. fig.* 1.)

"After a time these larvæ change into the pupa state, answering to the chrysalis of the moth and caterpillar, although the other tribes of insects do not spin cocoons. Sometimes insects are quite active when in the pupa state, and run or swim about with great agility. From the pupa the perfect insect is developed, often very different in appearance and habits from its former condition.

"Some have supposed that there is an analogy or resemblance between these changes in the insect tribes, and our condition before and after the general resurrection. Certain it is, that the Bible represents the life of the Christian in the other world as much more

perfect and glorious than it is here. This should be an inducement to us to serve our Heavenly Father with all humility and faithfulness, 'looking not at the things that are seen, but at the things which are not seen. For the things which are seen are temporal, but the things which are not seen are eternal.' "

"Before we retire to rest," continued their uncle, "Thomas can read us a little poem which I have selected, called the ant and the caterpillar. It is founded upon the subject we have just been talking about, and may teach you that nothing is so mean in appearance that it should be despised; and, that those who despise others may be mortified themselves at last."

Thomas then took the book which his uncle gave him, and read

THE ANT AND THE CATERPILLAR.

As an ant, of his talents superiorly vain,
Was trolling, with consequence, over the plain,
A worm, in his progress remarkably slow,
Cried—"Bless your good worship wherever you go!
"I hope your great mightiness wont take it ill;
"I pay my respects with a hearty good will."
With a look of contempt and impertinent pride,
"Begone, you vile reptile," his antship replied;
"Go, go and lament your contemptible state,
"But first, look at me, see my limbs all complete;
"I guide all my motions with freedom and ease,
"Run backward and forward and turn when I please.
"Of nature (grown weary) you shocking essay!
"I spurn you thus from me—crawl out of my way."
The reptile insulted, and vexed to the soul,
Crept onwards, and hid himself close in his hole;
But nature, determined to end his distress,

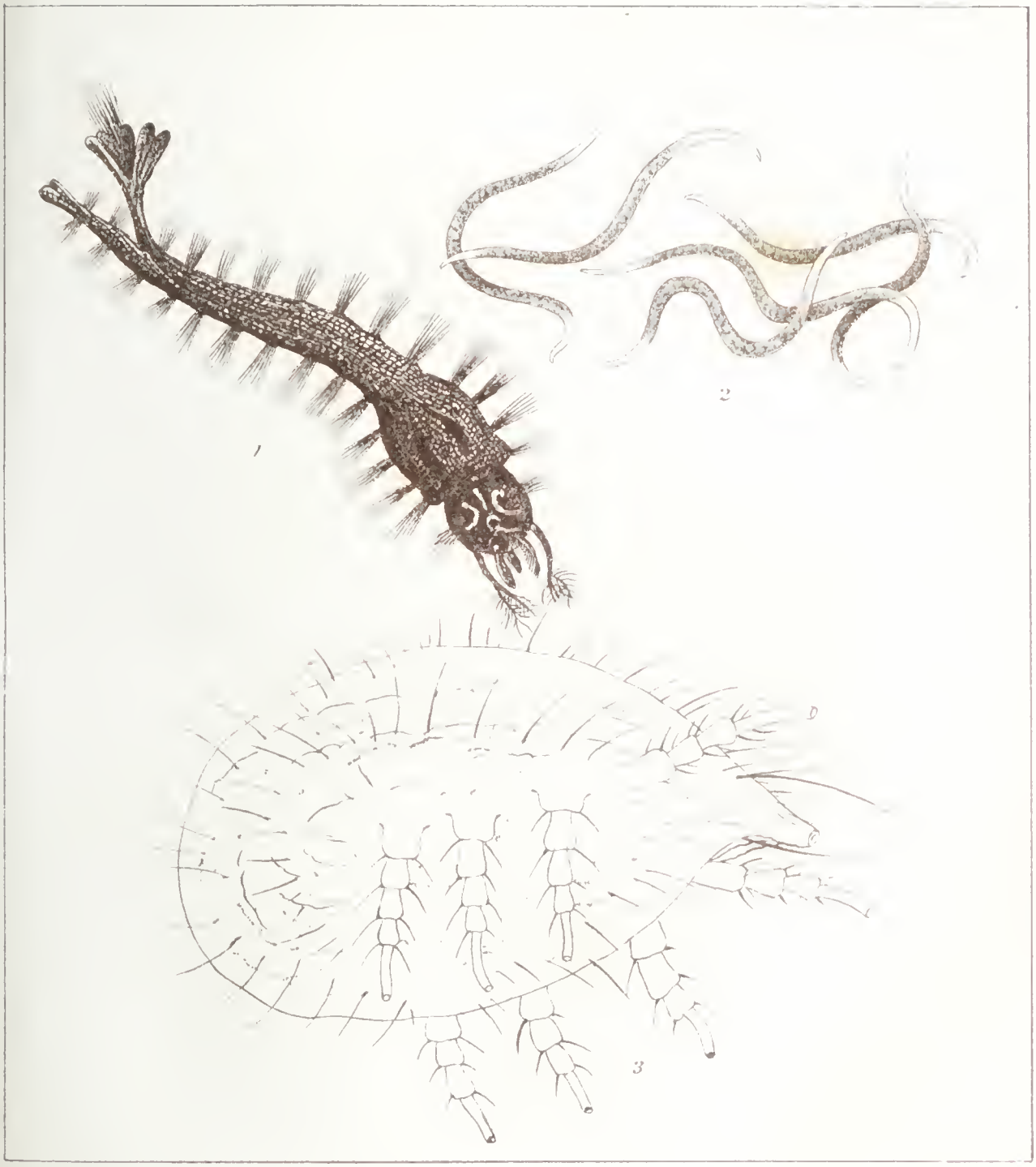
Soon sent him abroad in a butterfly's dress.
Ere long the proud ant, as repassing the road,
(Fatigued from the harvest, and tugging his load,)
The beau on a violet bank he beheld.
Whose vesture in glory a monarch's excelled;
His plumage expanded, 'twas rare to behold
So lovely a mixture of purple and gold.
The ant, quite amazed at a figure so gay,
Bowed low with respect, and was trudging away;
"Stop, friend," says the butterfly, "don't be surprised,
"I once was the reptile you spurned and despised;
"But now I can mount; in the sunbeams I play,
"While you must forever drudge on in your way."

Cunningham.

CHAPTER V.

ANIMALCULES.

"I am about to show you some of the most interesting creatures which the Microscope has ever yet revealed to our vision," said Mr. Simons to his nephews when they next met for the purpose of pursuing their investigations of the works of nature. "Heretofore I have exhibited to you only minute parts of objects, and these dead and motionless, but they have been sufficient to give you some idea of the use of the Microscope, and to prepare you in some degree to apply



1. Larva of Musquito. 2. Eels in Vinegar 3 Mite from Cheese.

it to the minute living creatures which I design to show you this evening. Before I show you the Animalculæ, (as they are called,) I will let you see under the Microscope the small animal called a cheese-mite, found in the dust on the outside of old cheese. It is no larger than the point of a small pin, and is scarcely visible to the naked eye." (*Plate VIII. fig.* 3.)

"What a strange animal!" cried William. "It has eight legs and is covered with hairs. I did not think there were such creatures on cheese."

"The cheese-mite," said Mr. Simons, "belongs to a tribe of insects called *Acari*, of which there are numerous kinds. One species, the harvest-bug or tick, insinuates

itself beneath the skin and is exceedingly troublesome. The irritation of another species of these insects, the itch-insect, produces a most inveterate disease. I will now put under the Microscope a drop of vinegar. The eel-like animals which live in vinegar are similar to those which inhabit sour paste, and are exceedingly active. (*Plate VIII. fig.* 2.) They are large enough to be just distinguishable by the naked eye when a small quantity of good vinegar in a wineglass is held between the eye and a strong light."

"I have heard," said Thomas, "that there are thousands of animals in every drop of water we drink."

"That is not exactly true," replied their uncle. "Pure water has very few, if any

animals in it, but if it be stagnant, or contain vegetable matters, there are generally a very great number. These little animals are called Animalcules or Infusoria. If you put a drop of sour paste in water, or put a bunch of some sort of vegetable, as hay or sage leaves, into water, in a short time it will contain thousands, yea millions of Infusoria. The more beautiful kinds of Animalcules, however, are to be met with in pools or in ditches of running water. Oftentimes in ponds the stems of plants will appear covered with a sort of slime or mucus. This appearance is owing to an extensive colony consisting of innumerable Animalcules. The thin shining film, which sometimes covers plants in pools of water, assuming the varied hues

of red, brown, yellow, green, and blue, is made up also of these creatures. Some species inhabit the clear fresh water of lakes and rivers. Others live in the briny ocean. When sailing on the ocean at night, I have looked over the side of the vessel and have seen sparkles of light shining beautifully in the spray. Sometimes there are many hundreds of these spangles. It is called the phosphorescence of the sea, and is owing to the presence of Animalcules and other animals, which emit a light when disturbed, similar to the glow-worm, or fire fly on land. By repeatedly filtering water taken up fresh from the sea, Professor Ehrenberg was enabled to obtain the phosphorescent Animalcules and observe them under the Microscope.

"Infusoria appear wherever decaying animal or vegetable substances are found in water, and are no doubt useful as scavengers of creation, destroying what would otherwise taint the air, and produce disease. They serve also for food to animals higher in the scale of creation than themselves, who in their turn support the existence of others. Thus all creation is linked together by a chain of mutual dependencies, and we know not how greatly the loss of any particular kind might be felt. Sir James Ross, in his Antarctic Voyage, speaking of a small fish found by him in the South Seas, and stating by what means it and many others are fed, says, 'All are eventually nourished and sustained by the minute infusorial Animalcules,

which we find filling the ocean with an inconceivable multitude of the minutest forms of organic life.'

"Animalcules have either a soft naked body, or are covered with a transparent shell, called a *lorica*. This shell, or shield, (so called because it does not in all cases cover the whole body,) is generally composed entirely of silica, or flint; but sometimes it is formed of lime with a portion of oxide of iron.

"Professor Ehrenberg says, 'with lime and soda, we can prepare glass out of invisible Animalcules.' Thus it would not be impossible to manufacture the lenses of a Microscope out of the shells of infusoria!

"It is a most astonishing fact that a drop of water on a glass slide, which to the naked

eye exhibits but a few minute vegetable fibres, and a small quantity of dust or sand, should under the Microscope be seen to contain a crowd of animals, so curious and beautiful that we can hardly bear to lose sight of them by withdrawing the eye from the instrument.

"Some are darting through the water with great rapidity, while others are pursuing and devouring creatures more infinitesimal than themselves. Many are attached to a twig of vegetable matter by long delicate threads; (the *Vorticellæ, Plate XI. fig.* 2.) several have their bodies inclosed in a transparent tube, from one end of which the animal partly protrudes and then recedes, (the *Flosculariæ, Plate XII. fig.* 1.) while numbers are

covered by an elegant shell or case. The minutest kinds, (the *Monads, Plate X. fig.* 1.) many of which are so small that millions might be contained in a single drop of water, appear like mere animated globules, free, single, and of various colors, sporting about in every direction. Numerous species resemble pearly or opaline cups or vases, fringed round the margin with delicate fibres that are in constant oscillation. (*The Vorticellæ, Plate XI.*) Some of these are attached by spiral tendrils; others are united by a slender stem to one common trunk, appearing like a bunch of hare-bells; (the *Carchesium, Plate XI. fig.* 3.) others are of a globular form, and grouped together in a definite pattern on a tabular or spherical membranous

case for a certain period of their existence, and ultimately become detached and locomotive; (the *Gonium* and *Volvox*, *Plate X. figs.* 5, 8.) while many are permanently clustered together, and die if separated from the parent mass. No organs of progressive motion, similar to those of beasts, birds or fishes, are observable in these beings; yet they traverse the water with rapidity, without the aid of limbs or fins; and, though many species are destitute of eyes, yet all possess an accurate perception of the presence of other bodies, and pursue and capture their prey with unerring purpose."*

* Mantell's Thoughts on Animalcules. London. 1846.

CHAPTER VI.

THE STICK AND LITTLE SHIP ANIMALCULES.

"Naturalists," said Mr. Simons, when he again met his nephews, "have often some difficulty in ascertaining whether a minute object belongs to the animal or vegetable kingdom. So gradually do these divisions of nature blend with each other, that no one can certainly tell where vegetable life ceases and animal life begins.

"In some of the vegetable matter, (*Confervæ*) which forms green slimy patches in standing water, the reproductive organs con-

sist of little green grains which fill the transparent tubes of which the plant is composed. When these are ripe, they leave the tubes, and have a motion so much like animal life, that in that state they have been taken for Animalcules. In the green ditch-laver (*Ulva Bullata,*) these microscopic grains have a very rapid movement, as if chasing each other. In time, two approach, and touch one another, then retreat, touch and retreat again; then four combine to execute the same movement; and at last, the whole party thus grouped in forms, dance together in seeming confusion. After a time the motion ceases, and they form the new substance known as *Ulva.*

"From this account it will be easily seen

how difficult it must be to classify and arrange some of these minute parts of creation. With very many Animalcules, indeed, no difficulty can possibly exist. They present so many clear evidences of sensation and voluntary motion as to leave no doubt upon the mind as to their real place in the catalogue of animals.

"The *Desmidieæ*, however, a group of minute beings formerly classed by Professor Ehrenberg among Animalcules, in the family *Bacillaria* (or stick Animalcules,) have been regarded by other observers as belonging to the vegetable kingdom. They form very conspicuous objects in nearly every drop of water taken from a stagnant pool. They are, like other plants, of a green color,

and are formed of vessels or cells containing a green substance. These cells, or joints separate either partially or completely ; some genera forming long filaments by the union of many cells, and others appearing only in pairs. You may see several kinds, or species of *Desmidieæ* upon this slide now under the Microscope. (*Plate IX.*)

"The long, pale, green filament to the left (*Plate IX. fig.* 1.) is a species of the genus *Desmidium*, or chain-wanded Animalcules of Ehrenberg; (*Desmidium Swartzii*, Swartz's Desmidium,) and is formed by a number of cells which are triangular and flat. Another species, having four sides (*Desmidium Quadrangulatum*, or Quadrangular Desmidium,) is more rare. Below this you observe a flat,

oval, or roundish form, toothed at the edge, besides having deeper divisions. It is called *Micrasterias Denticulata*, or Toothed Micrasterias. The genus to which it belongs (*Micrasterias*, or Little Star Animalcules,) has all its species round and flat, deeply divided into two lobed segments or cells, notched, or cleft at the edges, sometimes even rayed. The mode of increase is remarkable; the two segments are united by a narrow band or tube, which produces two new minute segments, which gradually increase, and separate the two original portions, each of which takes one of the newer formations with it. This singular process is constantly being repeated.

"The *Euastrum*, or Star Disk Animal-

cules, somewhat resemble the last genus, but the species are more oblong in form, and have circular protuberances on the surface *Euastum Oblongum*, (*Plate IX. fig.* 3.) is common in pools.

"In the genus *Cosmarium*, the segments are more or less round, and neither toothed nor rayed at the edge. The species you see (*Cosmarium Margaritiferum*, *Plate IX. fig.* 4.) is rather abundant."

"There is one object towards the top of the field of view," said William, "which is covered with short spines, each spine having several points. What is it called?"

"That," said Mr. Simons, "is a species of *Xanthidium*, or Double Bar Animalcules. (*Xanth: armatum*, *Plate IX. fig.* 5.) To the

right of that object is one very curious; the *Arthrodesmus Convergeus*, (*Plate IX. fig.* 6.) which has a single spine on each side of a segment. The spines in this species curve toward each other. *Arth: incus*, has the spines diverging outwardly, and the ends truncated.

"The genus *Staurastrum* appears at first view to differ very little from the last. The species on the slide, (*Plate IX. fig.* 7.) is the *S. Cuspidatum.*"

"What finger-like object is that in the middle of the drop?" inquired Thomas.

"That," continued Mr. Simons, "is a species of *Closterium*, or Spindle Animalcules; which is an interesting and striking genus. There are above twenty species. *C. Acer-*

osum, or Needle-shaped Closterium, (*Plate IX. fig.* 8.) is a very pretty object; bright, green, and very slender in form. *C. Moniliferum*, the Pearl or Necklace bearing Closterium is rather crescent-shaped, with a line of transparent dots down the middle. *C. Dianæ*, or Bow-shaped Closterium, (*Plate IX. fig.* 9.) is quite crescent shaped, small and slender. *C. Setaceum*, the Bristle-shaped Closterium, (*Plate IX. fig.* 10.) is perhaps the most beautiful. It is very slender in the centre, the ends tapering into long beaks and rather curved, which give it an elegant form.

"*Spirotænia* greatly resembles *Closterium* in size and general form; but it is easily distinguished by the green matter forming a

spiral line from one extremity to the other; there is no mark of division in the centre, and the ends are round.

"Occasionally may be seen very minute bundles of green objects, like little faggots; these belong to the genus *Ankistrodesmus*, and there is but one species, *falcatus*.

"The next genus *Pediastrum*, is composed of many species, all being more or less like a star; they are formed of several little cells, four or more united together either in a single or double circle. The species here seen are *P. pertussum*, (*Plate IX. fig.* 11.) and *P. Napoleonis*, (*Plate IX. fig.* 12.)

"*Scenedesmus* comprises little objects composed of from two to ten minute cells, arranged in a row, instead of in a circle as in

the last genus. *S. Quadricaudata* (*Plate IX. fig.* 13.) is common.

"The second section of the family *Bacillaria* are indicated by the term *Naviculacea.* Ehrenberg, and many other naturalists have regarded them as undoubtedly belonging to the animal kingdom. Dr. Meyen, however, regards such a classification as of doubtful propriety. He seems inclined to refer the whole of this family to the vegetable world.

"The genus *Navicula*, or Little Ship Animalcules, is so called from the resemblance of the individuals, both in form and motion to a little boat. The species are very numerous, and many of them are found in a fossil state. The bright colors and delicate markings of the lorica, or shield, which is silici-

ous, or flinty, make these objects very attractive. Some of them serve for test objects for the highest powers of the Microscope; their dotted or striated appearance being often difficult to observe. *N. Viridis*, or Green Navicula, (*Plate IX. fig.* 14.) *N. Amphisbæna*, (*fig.* 15.) and *N. Acus*, or Needle-shaped Navicula, (*fig.* 16.) are often met with.

"The *Gallionella*, or Box-chain Animalcules are a very singular genus. The lorica when lying on its face resembles a coin. One species, *G. Ferruginia*, or rust-like Gallionella, is found in chalybeate waters, and where it abounds is often taken for precipitated oxide of iron. Its lorica is composed of silicate of iron.

"The genus *Bacillaria*, the zig-zag, or True-stick Animalcules, from which this family takes its name, is composed of bodies of singular construction, which seem originally to form connected lines, but when mature, separate only in part, forming zig-zag chains. *B. Vulgaris*, the common Bacillaria, (*Plate IX. fig.* 17.) is by many botanists regarded as a vegetable, and named *Diatoma Floculosum*. *B. Cuneata*, or the Wedge-shaped Bacillaria, is another species, the form of which may be seen in the specimen. (*Plate IX. fig.* 18.)

"The fragile little wand Animalcules (*Genus Fragilaria*) may be distinguished from Navicula by being square at the ends. A specimen of this genus, (*F. Rhabdosoma*,)

you may see towards the right hand. (*Plate IX. fig.* 19.)

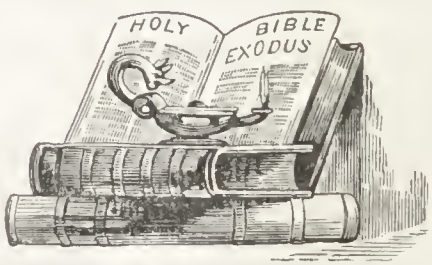
"The next section of the *Bacillaria* family is called *Echinellea*. The genera in this section are distinguished by being attached at one extremity to weeds, &c. One species of this family (*Synedra Ulna*, or, the common yard or ell-measure Animalcule,) is sometimes found attached to infusoria of the Vorticella tribe, having other species of *Echinella*, of the genus *Podosphenia*, or wedge little plate Animalcules, growing upon it; thus affording an example of one parasite growing upon another. The individuals of the genus *Gomphonema*, (the wedge little tree Animalcules,) are wedge-shaped, but are arranged in groups so as to appear much like a little

tree. Those of the genus *Echinella*, (the palm Animalcules) form a cluster like a fan. Some of them are quite large, forming by their aggregations a tree from 1–12th to 1–6th of an inch high. They are principally found attached to sea-weeds. (*Algæ.*)

"Another section of this interesting family, (*Lacernata*,) is characterized by having a double lorica, or shield; but a description of the different species would be too long and tedious for you. There is one genus however which has been appended to this family as a distinct tribe, (*Acineta*,) which is exceedingly interesting. It is found attached to small water plants. The body is small and round, or bell-shaped, having a number of rays, or horns, each having a knob at the

end, reminding you of a pin cushion with pins in it ready for use.

"All this will serve to show what singular varieties of form are found among these minute parts of creation, all having reference to the peculiar habits and wants of the individuals themselves. I think that nothing can more clearly and fully prove the truth that Divine Providence has a care over the minutest work of His hands."



Sinclairs lith

1. Monas crepuseulum.
2. Doxococcus miber.
3. Trachelomonas volvocina.
4. Pandorina morum.
5. [illegible] pectorale.
6. Syncra uvella.
7. Eudorina elegans.
8. Volvox globator.
9. Astasia hæmatodes.
10. Euglena sanguinea.
11. Dinobryon sertularia.
12. Amæba princeps.
13. Diffugia proteiformis.

CHAPTER VII.

MONADS AND CHANGEABLE ANIMALCULES.

"I will now show you," said Mr. Simons, "a drop of stagnant water from a pond, which contains Animalculæ of the class *Polygastria*."

"What a multitude of little animals there are moving about," said William, "some of them no larger than a point; others seem like a chain of beads, and have a trembling motion; while the larger ones are actively swimming about." (*Plate X. fig.* 1.)

"Those Animalcules," said Mr. Simons,

"which look like a string of beads are called *Vibriones*, or trembling Animalcules, from the nature of their motions; the rest are different species of *Monads*. (Family *Monadina*.) It is certainly wonderful how they can be so active, for the most of them are entirely destitute of external organs. Some of them however are found when examined with very high powers, to be covered with hairs; others have a proboscis; and others again a tail. None of them have a lorica or shield. They increase by dividing or subdividing themselves into two or four parts, each part becoming a perfect individual. The smallest species you see in the specimen, (*Monas Crepusculum*, or twilight Monad,) is curious as being the smallest of known living

beings, yet were the power of our instruments much increased, we should doubtless see some much smaller.

" 'Take any drop of water from the stagnant pools around us,' says Professor James, 'from our rivers, from our lakes, or from the vast ocean itself, and place it under your Microscope; you will find therein countless living beings, moving in all directions with considerable swiftness, apparently gifted with sagacity, for they readily elude each other in the active dance they keep up; and since they never come into rude contact, obviously exercise volition and sensation in guiding their movements. Increase the power of your glasses, and you will soon perceive, inhabiting the same drop, other animals, com-

pared to which the former were elephantine in their dimensions, equally vivacious, and equally gifted. Exhaust the art of the optician, strain your eye to the utmost, until the aching sense refuses to perceive the little quivering movement that indicates the presence of life, and you will find that you have not exhausted Nature in the descending scale. Perfect as our optical instruments now are, we need not be long in convincing ourselves that there are animals around us so small, that in all probability human perseverance will fail in enabling us accurately to detect their forms, much less fully to understand their organization.'

"The round animal to the left hand, the red revolving Monad, (*Doxococcus Ruber*,

Plate X. fig. 2.) is a very lively little Animalcule, having a peculiar rolling motion. There are several species of this genus, as the globular Doxococcus, (*D. Globulus,*) which is transparent; the green Doxococcus (*D. Pulvisculus,*) and the irregular shaped Doxococcus (*D. Inequalis.*)

"The family *Cryptomonadina* is distinguished by a lorica or shell. There is one species at the right hand of the upper part of the field of view. It is a species of *Trachelomonas*, or truncated Monads. (*Trach. Volvocina*, revolving Trachelomonas, *Plate X. fig.* 3.) It has a proboscis, on which account it is named; and is especially curious from the fact that though it is of a green or brown color, it always presents a red ring at the

circumference, no matter how quickly it may revolve.

"The third family of the class *Polygastria*, (*Volvocina*, or revolving globe Animalcules,) contains many extraordinary creatures. Many individuals in the different species are grouped together in masses, so that what appears to be at first sight but one, is in reality a number of Animalcules enclosed in a transparent envelope, which expands in size as the individuals approach maturity; and at last opens, or bursts, and sets them at liberty, when the same process is repeated with each.

"The genus *Pandorina*, (Berry-like globe Animalcules,) is very beautiful. A green species, resembling a Mulberry, (*P. Morum*,) is seen under the instrument, to the left hand.

(*Plate X. fig.* 4.) One of the group is seen separated a little below it.

"The next cluster (*fig.* 5.) is very curious. It is called the *Gonium Pectorale*, or Breast-plate Gonium, (or tablet Animalcule,) from a fancied resemblance to the Breast-plate of the Jewish High Priest. It consists of sixteen spherical Animalcules enclosed in a flat transparent shell. Each of them has a double proboscis. The color is bright green, and the four central individuals are generally larger than their companions. They increase by self-division. The whole group divides into four, each of which contains four individuals. These individuals likewise divide into four each, which makes the original number sixteen.

"The cluster of yellowish oval bodies towards the right hand is called *Synura Uvella*, (the Grape Synura, *Plate X. fig.* 6.) Each Animalcule is provided with a tail which is attached to the bottom of a cell in the general envelope.

"*Eudorina Elegans*, (the elegant Eudorina, *Plate X. fig.* 7,) seen to the left of the last, is a beautiful creature. The Animalcules have no tail, but are furnished with a sparkling red eye, and a proboscis. They are exceedingly delicate, so that it is difficult to preserve them alive more than a day or two.

"The cuirass Monads, (*Genus Chlamidomonas*,) are characterized by being deficient of the tail, but provided with a beautiful red eye, and a double proboscis. The lorica

bears the form of a little box. The *Chlamidomonas Pulvisculus*, or Dust Monad, is so called from their often forming a dust-like stratum on the surface of the water. These creatures form the larger portion of the green matter which gives color to the water in ponds, water-butts, and puddles, in summer and autumn, and especially after a storm. They exist frequently in great quantities, and when they die their bodies float and form a green stratum on the water.

"The most interesting of the family *Volvocina*, is the *Volvox Globator*, or Globe Animalcule, which attains a large size, being from 1-30th to 1-350th of an inch in diameter. It was discovered by Leeuwenhoeck, about 150 years ago, who supposed it to be a

single animal; but better instruments have shown that it consists of a group of Monads fixed in a globular envelope or case, which is hollow in the middle. Each of these Monads has a red eye speck and two long spines or horns, (proboscides.) Like the individuals of the *Gonium Pectorale*, it is connected with its associates by certain processes or tubes, as you may see. (*Plate X. fig.* 8.)

"Inside the hollow globe you observe several young clusters. When these are mature the outer envelope bursts and sets them free.

"I will now increase the magnifying power of the instrument," continued Mr. Simons, "to 2000 diameters, so that you may more readily observe a single Animalcule. (*fig.* 8.*)

"The family *Astasiæa* has the power of

changing the shape of the body at pleasure. The eye is very conspicuous except in the genus *Astasia*, whose species have no eye. The *Astasia hæmatodes*, or blood-red Astasia, (*Plate X. fig.* 9.) is often the cause of considerable alarm to persons residing in the vicinity of waters wherein they are found, for on account of their immense numbers, the water assumes a blood-red color.* This spe-

* A remarkable account of such a phenomenon, is recorded in D'Aubigne's History of the Reformation. "A widow chancing to be alone before her house in the village of Castelen Schloss, suddenly beheld a frightful spectacle,—blood springing from the earth all around her!" The villagers and monks of a neighboring convent, witnessed the same appearance upon the stones of the house, and in a neighboring pond, and an account was sent officially to the lords of Berne and to Zwingle.

cies contracts and dilates itself in a curious way. It is first green, and afterwards becomes red.

"You may observe also another species of this family, *Euglena Sanguinea*, which is also blood-red. (*Plate X. fig.* 10.) It is distinguished by the presence of an eye and a proboscis. There are several species belonging to the same genus, which differ in color and form.

"There is also a curious little creature belonging to this family, but which attaches

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No doubt the occurrence was magnified by their fears and superstition, yet it had its cause doubtless in the rapid development of myriads of animalcules, similar to those mentioned above.

itself to other bodies by a foot stalk. It is often found as a parasite upon the little water flea, and other crustaceous creatures, and on this account has been called by Ehrenberg, the friend of the water flea, (genus *Colacium*) although the term may be of rather questionable propriety.

"The family *Dinobryonia* has a lorica in the form of a little pitcher, while the Animalcule within has the power of changing its shape at will. The *Dinobryon Sertularia*, is found in groups which bear some resemblance to a flowering shrub. This creature is not readily seen on account of its transparency, but by patient attention it may be perceived rolling along in the field of view. The cluster you see is composed of nine living

Animalcules, and two dead ones. (*Plate X. fig.* 11.)

"A most singular Animalcule, (genus *Amœba,*) gives name to the family, *Amœbæa.* It has neither foot, eye, nor proboscis. It appears like a transparent bladder or a lump of jelly, but it has the power of putting out at all parts of the body processes which help it to creep slowly along. These it continually contracts and dilates, so that it is always changing its form; hence it is called the Proteus. *Amœba princeps*, or the great Proteus, (*Plate X. fig.* 12.) is of a pale yellow color.

"The family *Arcellina* differs from the last by having a lorica in the shape of a pitcher or dish, while the body is soft and gelatinous, and in some cases seems to flow as it were

from the opening or mouth of the lorica. It moves by means of soft variable processes which protrude beyond it. *Difflugia Proteiformis*, (*Plate X. fig.* 13.) is of a globular or oval form and has its lorica covered with minute grains of sand."

CHAPTER VIII.

THE TRUMPET AND BELL-SHAPED ANIMALCULES.

While Mr. Simons was arranging the Microscope, the attention of the two boys was taken up with a small phial in which were seen some small strange looking animals, visible to the naked eye. They were mostly attached to the stem and leaves of a small plant, and were from a quarter to three quarters of an inch long. At the free extremity they carried several long delicate arms. Some of these animals appeared to contract or shrink into a little round mass,

resembling jelly, when the arms looked like little prominences or finger-like projections.

On inquiring of their uncle, he informed them that the animal was called the *Hydra*, and that it was often found in ponds and streams, and belonged to the class of animals which Naturalists called *Polypi*.

He told them of the strange property it has of multiplying itself when cut in several pieces, each piece becoming a perfect animal.

To show them the use of the long arms, he told them to watch while he dropped a small worm into the bottle. They saw the worm sink slowly down in the water until it touched one of those thread-like arms, when it became instantly entangled, and was deprived of life and motion as if by an elec-

tric shock. It was then drawn up into the mouth and swallowed, the body of the Hydra being at the same time distended.

"These animals," said Mr. Simons, "are very voracious. Sometimes two of them will seize the same worm, when a desperate struggle ensues, and the stronger polype will sometimes swallow his adversary as well as the prey they were contending for. The swallowed hydra however is soon disengorged without much harm.

"I will now put under the Microscope this little twig which seems covered with mucus, and shall be disappointed if there are not a number of Animalcules of the family *Vorticellina* upon it.

"Yes, there are some. But in order to

show them more distinctly I will put a drop of this solution of carmine into the water. The advantage of the carmine is that the particles of coloring matter render the water less transparent, so that we may more readily see the cilia, or little hairs, which are in constantly rapid motion, particularly about the mouth. The Animalcules, too, will often swallow the carmine, and by this means we shall be able to see the internal organization of these creatures.

"The Animalcules now in view, (*Plate XI. fig.* 1.) are called Trumpet Animalcules, (*Genus Stentor*,) from their shape. They are of a large size, and visible to the naked eye. One species, (*S. Mulleri*,) Muller's Stentor was described by Tremblay as a

white funnel-like polypi. When swimming they are usually contracted to somewhat the form of an egg, but when attached are more like a trumpet. *S. Roesellii*, (Roesel's Stentor, *Plate XI. fig.* 1.) is rather more yellow in color than the last. They are covered with cilia which are largest round the mouth and are in constant motion.

"The genus *Vorticella* is one of the most interesting among the Infusoria. The species you see, (*Plate XI. fig.* 2.) *Vorticella Convallaria* appears to have been the first infusorial Animalcule discovered. Leeuwenhoek, the discoverer, found it in stagnant rain water, at Delft, in April 1675. It has a bell-shaped body, is perfectly transparent, and is attached by a flexible stalk of considerable

length to weeds, etc., so that it can be watched with great ease. The fringe of cilia round the mouth are in constant motion, producing a strong current in the water, which brings the food within their reach. When anything alarms these creatures, they immediately contract a strong muscle in the stalk, which causes it quickly to coil up, so that the body is removed to a distance. In a short time it slowly uncoils, and the Animalcule renews its occupation.

"The *Vorticellæ*, like all the rest of the animalcules which we have yet examined, as well as many others, are characterized by having numerous stomachs, which you may very readily see as spots in their bodies, now that they have swallowed some of the carmine,

They increase rapidly by three different methods;—by depositing eggs; by self-division; and by buds, in a similar manner to vegetables.

"The genus *Carchesium* is similiar to *Vorticella*, but the individuals are grouped upon one main stalk, which has the power of being contracted in coils. It has quite a pretty, tree-like appearance. The species in view is *C. Polypinum*, (*Plate XI. fig.* 3.)

"The next family of the class Polygastrica, called *Ophrydina*, appears to be composed of true Stentors or Vorticellæ, enclosed in a gelatinous or membranous lorica or shell. Two species are seen on the same twig with the two last, viz., *Vaginicola Crystallina* and *Cothurnia Imberbis*," (*Plate XI. figs.* 4 *and* 5.)

"What singular animalcule is that," inquired Thomas, "with the long neck, which creeps about at the bottom of the water?"

"That," said Mr. Simons, "is the white swan-like animalcule, (*Trachelcerca Olor, Plate XI. fig.* 6.) It is a very singular creature. The truncated purse animalcule, (*Bursaria Truncatella, Plate XI. fig.* 7,) is also an interesting being. It is large, and visible to the naked eye, being found in water where there are decaying beech leaves. The internal cells are very transparent, and frequently contain the bodies of other infusoria which have been swallowed.

"The long slipper animalcule, (*Paramecium Aurelia, Plate XI. fig.* 8,) is often very abundant in stagnant water. Professor Ehren-

berg thinks that he has seen in them some traces of a nervous organization. They appear to have the sense of taste, for if you mix carmine and indigo together in the water which contains them, some will take only one substance and some the other, as indicated by the color of their stomachs. These animalcules, fed with color, may be dried upon a glass slide, and thus rendered permanent objects for the microscope.

"The last genus I shall mention in this class is *Euplotes*, (the skiff or boat animalcules.) They are of an oval form, very transparent, and brightly colored with spots of green and red. They have cilia, as well as certain hair-like appendages, which by their quick motions enable the animalcule to

move most rapidly through the water; they also dart back suddenly, and, turning round, again advance to the place where they were feeding. They make a powerful current with the cilia near the mouth. *E. Charon, Plate XI. fig.* 9, (the pearled Euplotes, or the little Charon,) is perhaps the most common.

"When looking at the astonishing variety of animated beings," continued Mr. Simons, "which swarm in a few drops of stagnant water, I am often reminded of those beautiful lines of the poet Thomson.

"Full nature swarms with life; one wondrous mass
Of animals, or atoms organized.
. . . . . The flowery leaf
Wants not its soft inhabitants. Secure

Within its winding citadel, the stone
Holds multitudes.
Where the pool
Stands mantled o'er with green, invisible
Amid the floating verdure, millions stray;
These, concealed
By the kind art of forming heaven, escape
The grosser eye of man. . . . . .
Let no presuming, impious railer tax
Creative Wisdom, as if aught were formed
In vain, or not for admirable ends.
Shall little haughty Ignorance pronounce
His works unwise, of which the smallest part
Exceeds the narrow vision of her mind?
As if upon a full proportion'd dome,
On swelling columns heaved, the pride of art,
A critic fly, whose feeble ray scarce spreads
An inch around, with blind presumption bold,
Should dare to tax the structure of the whole!
And lives the man, whose universal eye
Has swept at once th' unbounded scheme of things;
Marked their dependence so; and firm accord,

As with unfaltering accent to conclude
That this availeth naught! Has any seen
The mighty chain of beings, lessening down
From Infinite Perfection to the brink
Of dreary nothing, desolate abyss?
From which astonished thought, recoiling, turns?
Till then alone let zealous praise ascend,
And hymns of holy wonder, to that POWER,
Whose wisdom shines as lovely on our minds,
As on our smiling eyes his servant, sun."

CHAPTER IX.

WHEEL ANIMALCULES.

"THE animalcules we have hitherto examined," said Mr. Simons, "with very many other species, amounting to about 600 different kinds hitherto discovered, belong to that class of Infusoria, called by Professor Ehrenberg, (who has paid more attention to this subject than any other person,) *Polygastrica*, from two Greek words which signify "many stomachs;" all of these creatures having a number of little sacs or stomachs, designed

for the reception of food, as you saw in the *Vorticellæ*. Many of these Polygastrica have very singular and beautiful forms. About two hundred species more belong to the class called *Rotifera*, or wheel-bearing animalcules. These are so called, because the rows of cilia or hair-like organs about the mouth are so arranged, that when in motion, they look like the rotation of a wheel. Many of these Rotifera are highly organized. Some of them have a foot or pedicle, which is furnished with a sucker, which serves to fix the body upon a stick or other foundation, while it rotates its arms in search of prey. Many species of them are furnished with strong jaws and teeth for masticating the smaller animals, etc., on which they feed.

FIG. 3.

"*A*. fig. 3, represents the jaws of the *Notommatta*. You see two long teeth, one in each jaw, forming a pair of powerful nippers, well formed for seizing and tearing in pieces its prey. *B*, exhibits the teeth of the *Melicerta*, which consists of a set of toothed hammers for pounding and crushing its food. *C*, is the jaws and teeth of the *Stephanoceros*.

"The individuals of this class have but a single digestive cell, which is in the form of a tubular alimentary canal. They are usually hatched from eggs.

"Some species are always attached to

water-plants, etc., others are free or attached at pleasure.

"There are indications of a nervous system in several genera, and eyes have been observed in 150 species.

"The first family we shall notice is the *Floscularia* or flower-shaped animalcules. These animalcules have one simple, continuous rotatory organ, the margin of which is more or less deeply lobed or undulated. The body is enclosed in a cylindrical case or sheath, which is fixed at the bottom, and open at the upper extremity, from which the rotator and upper part of the body can be protruded.

"*Floscularia Ornata* (*Plate XII. fig.* 1,) is a beautiful example of this family. Its case

is of a crystalline appearance, and its body quite transparent, so that the internal organs are distinctly visible. It is furnished with very long cilia and with strong teeth. It feeds on the Polygastrica, and will often swallow quite large species. The eggs are deposited within the case, and are of an oval form. The two red eyes of the young Floscularia may often be seen through the transparent shell before it is hatched.

"The *Stephanoceros*, (or Crown Animalcule,) is another genus of this family. One species, *S. Eichhornii*, (Eikhorn's Stephanoceros,) is a wonderful creature, and of considerable size, but unfortunately very rare. Its case is transparent like glass. Its rotatory organ has five arms, each furnished with fif-

teen rows or whirls of delicate cilia, which are in constant motion. These arms it sometimes employs to seize its prey; at other times they are bent over like a crown, hence its name.

"The *Limnias*, (or Water Nymph,) has but two lobes to its rotatory organ, and the case is generally of a brown colour, and often covered with other substances which adhere to it. The Hornwort Limnias (*L. Ceratophylli, Plate XII. fig.* 2,) has a singular appearance while feeding; the rapid action of the short cilia round the rotatory organ seeming like a moving band of light round the edge.

"The *Melicerta*, or four leaved animalcules are very similar to the last, but have four lobes instead of two.

"Of the free genera belonging to the class Rotatoria, some are distinguished for the singularity of their form, and others for their incessant activity.

"The *Microcodon Clavus*, or bell Animalcule, (*Plate XII. fig.* 3,) is a beautiful little creature, being in shape like a bell. It has a long flexible foot, and two pincer-like points or teeth which project out of the middle of the rotatory organ.

"*Notomatta Longiseta*, (the long-forked Notomatta, *Plate XII. fig.* 4.) is quite curious. Its long double tail is often more than three times the length of its body. It is active, and frequently leaps about, being assisted by its long tail.

"*Synchæta Pectinata*, (the comb-bearing,

bristled Animalcule, *Plate XII. fig.* 5,) has a short conical body, with two styles or bristles, and two horns anteriorly. Professor Ehrenberg has suggested that these horns may be respiratory tubes as in some other tribes. Like many others of this class it is difficult to observe, owing to its lively motion. Sometimes, however, it fixes itself to some object by its tail, and may then be seen with more satisfaction.

"*Scaridium Longicaudum*, or long-tailed Springer, is named because of its leaps or springs, which movements are executed by means of its long forked foot. It differs from all Animalcules of this class by the length and jointed nature of the foot.

"Another leaping Animalcule is the *Poly-*

arthra Trigla, (the bristle-finned Animalcule, *Plate XII. fig.* 6.) Its body is oval, almost square, having six fins which seem like bristles, by means of which its leaps are effected. It is often observed to be infested with a parasitic Animalcule, the *Colacium*.

"The *Rattulus Lunaris*, (the sickle-shaped rat Animalcule, *Plate XII. fig.* 7.) is of very small size, with a curved foot. No cirri or beard has been observed in this genus, although the other parts of its organization are allied to the rotatorial Animalcules.

"Another species which you may find somewhat interesting is the *Distemma Forficula*, or pincer-footed Distemma. This species has a double foot, which is toothed, and much resembles a pair of pincers. It

has two red eyes, like many other Animalcules. Its mouth is furnished with cilia, and in addition, it has strong jaws, armed with two teeth each, which are extended when the creature seizes its prey.

"The *Lepadella Ovalis*, (Egg-shaped, scaled Rotatoria, *Plate XII. fig* 8.) belongs to a family of this class, whose species possess a lorica resembling the shell of a tortoise or crab. It is said to have no eye, yet it moves about with great precision.

"The *Mastigocerca Carinata*, (flesh-colored, whip-tailed Animalcule, *Plate XII. fig.* 9.) is another of the same family as the last. Its lorica has a singular shaped crest on the back.

"*Salpina Mucronata*, (the short spined,

stork-fish Rotatoria, *Plate XII. fig.* 10.) is another example. Its three-sided rough lorica is of curious form. The under side is flatly rounded, the back crested, with projecting sides. There are four points or projections at the head and three at the tail. It feeds chiefly, if not entirely upon vegetable matter.

"I will now," continued Mr. Simons, "put under the Microscope some individuals of the *Rotifer Vulgaris*, or common wheel-Animalcule, which I have procured by allowing some hay and sage leaves to soak in pure rain water, although I have frequently met with it in ponds. This Animalcule was discovered by Leeuwenhoek in 1702, and has been described by nearly every writer on the

Microscope since his time. When it moves, it has somewhat the appearance of a leech, for its cilia are withdrawn and a proboscis bearing its eyes is extended. Its motions are performed in a singular manner. It first fixes its tail and extends its body to its full length; it then fastens its head and draws its tail up to it. This process is repeated until it has arrived at the place desired; it then fixes itself by its tail, and thrusting out its cilia forms such currents in the water as may bring its prey within reach. The movements of the cilia are such that an inexperienced observer can hardly be satisfied that they do not actually move round like wheels. You may now look through the instrument. I have put some carmine into the water so

that you may see the currents produced by the cilia, as well as the stomach and intestine of the Animalcule." (*Plate XII. fig.* 11.)

"There is one of them," said William, "turning its wheels about very briskly."

"The spiral currents which the wheels make in the water are very curious," said Thomas; "I can see its red eyes too, and its curious teeth!"

"How is it that those organs about the mouth look so much like wheels, if they are not such in reality?" asked William.

"In order to see the real motions of the cilia, a very high magnifying power is required," replied their uncle, "as well as a good deal of experience in the use of the Microscope. Professor Ehrenberg has given

us an illustration, from which this cut is taken, which fully explains their motions. You will observe that the base of each cilia is fixed, while the point moves round in a circle represented by the dotted lines. At *a*, in the figure you will see an enlarged view of the cilia of this Animalcule, and at *b*, its eyes on its proboscis; *c*, are its jaws and teeth.

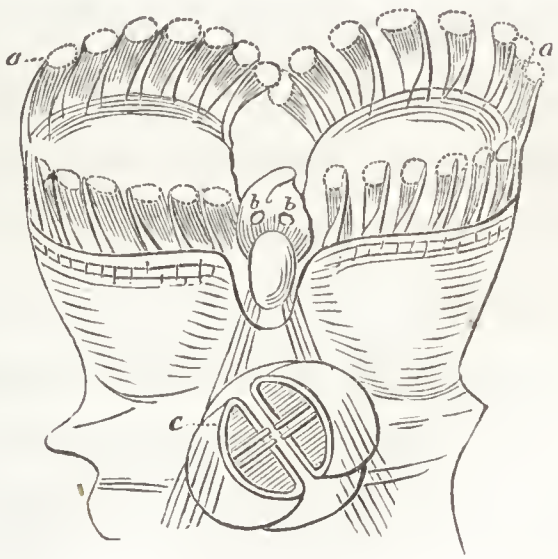


Fig 4.

"Perhaps the most remarkable circumstance connected with the Infusoria," continued Mr. Simons, "is their capacity for being resuscitated or revived, after having been apparently dried up for years. Dr. Mantell informs us that some Rotifers were alternately dried and rendered dormant, and then revived by the addition of water, twelve times, appearing at each successive resuscitation as active as at first. Professor Owen mentions having witnessed the revival of an Animalcule which had been preserved in dry sand four years."

"Fontana relates that he succeeded in the course of two hours, by means of a drop of water, in bringing to life a rotifera which had lain for two years and a half dried up

and motionless. Doyere gives us the following conclusions to which he arrived in the course of his experiments upon this subject. Rotiferæ come to life, *i. e.* pass from a motionless state to a state of motion, after having been exposed to varieties of temperature ranging from 11° to 113° Fahrenheit. They preserve the capability of apparent vivification in dry sand if heated up to 158°; but they lose it and cannot be revived afresh, if heated in moist sand to 131°.

"Yet the ordinary duration of these creatures varies from a few hours to several weeks at most. They often die from very slight causes. They perish frequently from sudden changes of temperature, as well as

from an alteration of the chemical composition of the water in which they live.

"In the cases before mentioned there can be no doubt but the Animalcules continue alive. On account of being carefully dried they retain a sort of latent vitality, like the seeds found buried with an Egyptian mummy, of which I have read somewhere, which grew when planted in a proper place, although it might have been three thousand years since they had been interred.

"The *Actinurus Neptunis*, (the Elongated three-toed Rotatoria, *Plate XII. fig.* 12.) greatly resembles the *Rotifer Vulgaris*, but is easily distinguished by the extreme length and wonderful formation of its tail, the joints

of which slide within one another like the tubes of a Telescope.

"The *Philodina Roseola*, or, Rose-colored Philodina is another member of this interesting group. 'I have observed,' says Ehrenburg, 'that this Animalcule, when kept in glasses, deposits its eggs in heaps, and the parent remains a long time with the young ones produced from them, forming a sort of family or colony, and which we are not to be hindered from ascribing to *a sense of company or family*, though the pride of man may laugh at it.'

"The last family of the class Rotatoria, is called *Brachionæa*, or Spine-bearing Animalcules. They have a lorica somewhat resembling the shell of a tortoise, and the rotatory

organs are often apparently divided into five parts, three central, and two lateral, although the latter alone constitute their rotatory organs, the others being merely ciliated portions of the front of the body.

"*Noteus Quadricornis*, (the four-horned egg-carrying Brachionus, *Plate XII. fig.* 13.) is an interesting Animalcule. Like two other genera of this family, it carries its eggs attached to the outside of the body, which gives it a very curious appearance. Its muscles are very strong, and its motions vigorous.

"*Anuræa squamula*, (*Plate XII. fig.* 15.) has no tail or foot. Most of them carry their eggs attached to their body. They possess an eye and swim very rapidly.

"*Brachionus Bakeri*, (Baker's Brachionus,) has a rough shell, with six unequal spines on the upper, and two long lateral ones on the lower end. These minute beings sometimes congregate in such numbers as to render the water milky and turbid.

"*Pterodina Patina*, (the Dish-like, winged Brachionus, *Plate XII. fig.* 16.) has an exceedingly delicate transparent lorica, quite flat, and destitute of the processes which characterize the other genera of this family. It has a double rotatory organ and a single conical foot having a suction disc at the end.

"How numerous are the particulars thus revealed to our minds by the Microscope! Yet the half has not been told us. We have

only been able to observe a few of those wonderful beings. How wonderful then is the Great Former of all! His nature is unsearchable, and his ways past finding out."

CHAPTER X.

FOSSIL SHELLS OF ANIMALCULES.

"Many families of Infusoria," said Mr. Simons, "particularly of the class Polygastria, are covered with a shield or shell, (called a lorica.) Some of these shells are of very curious forms and very beautifully marked and fluted. These shells are formed either of lime, flint, (silex,) or iron; and retain their form long after the destruction of the Animalcules which inhabited them. But the most wonderful fact relating to them, is the incredible number found in a fossil state

in various districts, constituting whole masses of soil and rocks of great extent and thickness.

In Sweden there is a sort of earth resembling fine flour, which is called edible earth, from its nutritive properties. It is often used for bread when mixed with flour. Humboldt tells us that hundreds of cart loads are consumed annually, and even more from fancy than necessity. This earth consists altogether of the shells of Animalcules. The layers of this substance are nearly thirty feet thick.

Peat bogs and swamps often contain masses of a white, marly, siliceous paste wholly made up of Infusorial shells. Professor Bailey discovered in a peat-bog, near West Point, layers, several hundred yards in ex-

tent, of a white earthy substance, wholly composed of these siliceous shields. Bog-iron ore likewise is composed of those shells which are made of iron.

The polishing slate of Bilin, in Prussia, which forms a strata fourteen feet thick, and the edible earth of Luneburg which is twenty feet thick, are composed of these animal remains. Yet it would take, it is said, forty one thousand millions of their skeletons to make a cubic inch, their weight being only two hundred and twenty grains. A single shield or skeleton weighs about the one hundred and eighty-seven millionth of a grain.

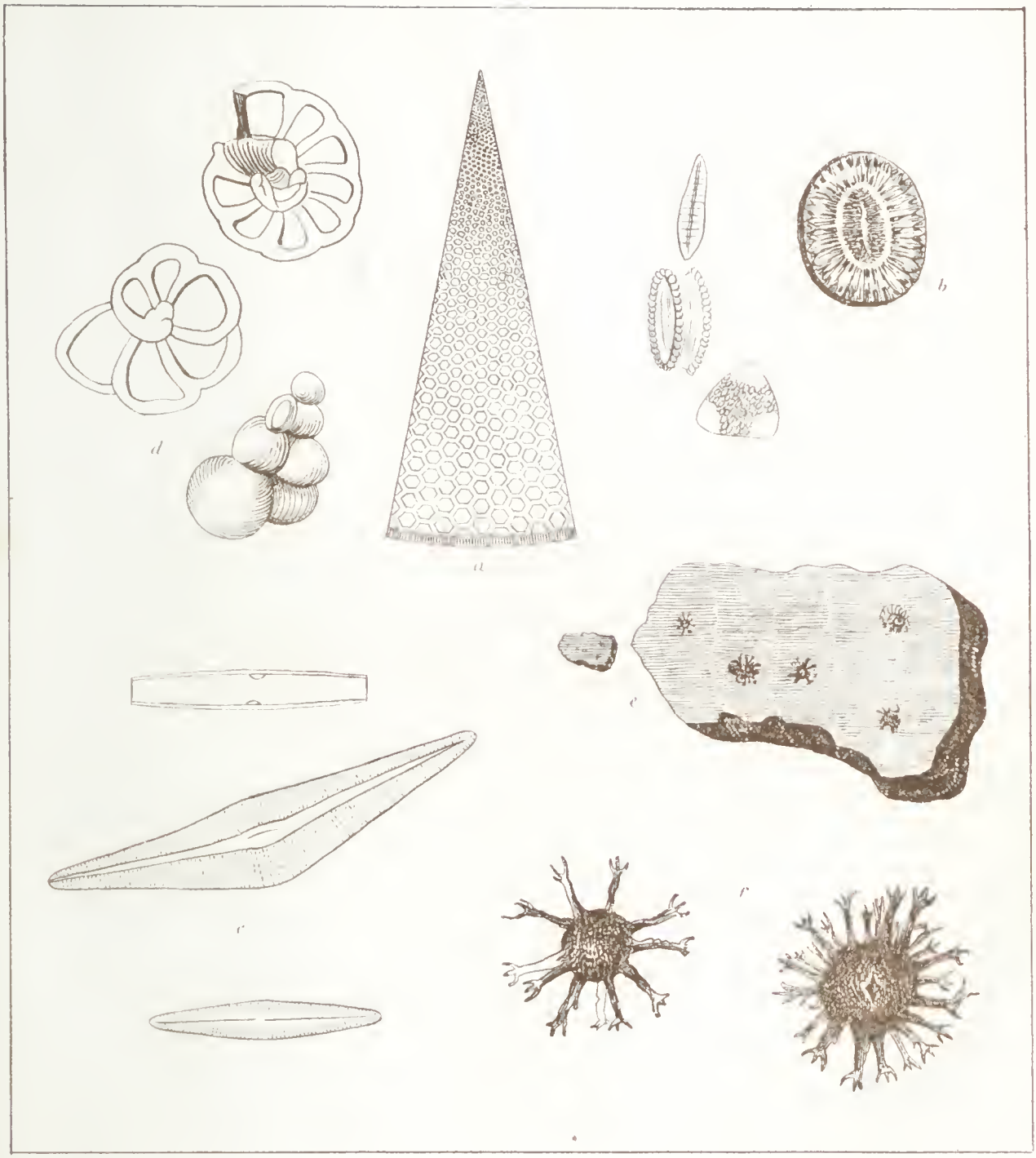
"In Virginia there are extensive beds of marl, which are almost wholly composed of such shells. The towns of Richmond and

Petersburg in Virginia are built upon strata of this kind.

"In some parts of Africa and South America there are found large quantities of animal and vegetable matter called Guano, which is brought to this country to serve the farmer for manure. This substance contains a good many shells of Infusoria, some of which are very beautiful.

"On this slide are several kinds of fossil Infusoria. The round flat shell which is marked so as to resemble the back of a watch, is called the *Radiated Coscinodiscus.* The oval shell to the right is the *Campilodiscus.* Those below, to the left are different kinds of *Naviculæ.* (*a, b, c, Plate XIII.*)

"On another slide you will see the curious



a Section of Coscinodiscus b Campylodiscus. c Navicular
d Foraminifera from Chalk e f Xanthidea in Flint

shells of the *Foraminifera*, or shells with holes through them, from the chalk beds. Nearly all the chalk in the world is composed of such shells, in which other shells, corals, &c., are imbedded, (*d*, *Plate XIII.*)

"Enclosed in the chalk we often find lumps or nodules of flint, and many such are broken and used as gun flints. Now if we take a small chip of such flint and cement it to a glass slide, in all probability we shall find, if we put it under the Microscope, a number of small animals, which once lived in the sea, and around which the flint was deposited when it was in a fluid state. Here is a slide which has a small thin piece of flint on it. Under the instrument we find no less than five animals of a radiated appear-

ance. With a higher power we find that they posess a central globular case or shell, from which radiate tubes or hollow spines, that terminate in fringed or divided extremities. The Animalcules are species of *Xanthidia.* (*e, f, Plate XIII.*)

"It is now time we should close our examinations. Many more wonderful things might have been noticed, but enough has been seen for the present. You have observed enough, my dear nephews," continued Mr. Simons, "to learn that the power and wisdom and love of God is seen in all, even in the most minute of the works of his hands. You may learn too that there is nothing too insignificant for his notice. The smallest Animalcule is provided for by His powerful

hand. You may also learn to be humble; for beyond all that we can know or see, even with our best instruments, there is much unknown, unseen; a Universe within the compass of a point, to use the language of Dr. Chalmers, 'so small as to elude all the powers of the Microscope, but where the Almighty Ruler of all things finds room for the exercise of His attributes, where He can raise another mechanism of worlds, and fill and animate them all with evidences of His glory.' "

THE END.

GLOSSARY.

ACARUS.—An insect of the mite kind.
ALGÆ.—Sea weeds.
ALIMENTARY.—Pertaining to food.
ANNULAR.—Ring shaped.
ARTERIES.—The vessels or tubes which convey blood from the heart.
AQUATIC.—Inhabiting the water.
ANIMALCULE.—A very small animal.
BOG IRON ORE.—A species of ore found in marshy places.
BOTANIST.—A student of Botany, (the science relating to plants).
CABINET.—A set of drawers.
CAPILLARIES.—The smallest blood vessels of the body, mostly invisible without a Microscope.
CARMINE.—A bright red coloring substance.
CELLS.—Hollows or cavities, generally enclosed, but sometimes communicating with each other.
CELLULAR TISSUE.—A substance composed by the union of a number of cells.
CHRYSALIS.—The state into which the caterpillar changes before becoming a butterfly.
CHALYBEATE.—A term applied to water, &c., containing iron.
CILIA.—Hairs or fringes.
CIRRI.—A beard or hair.
CLASS.—The different objects in Nature are arranged by Naturalists, first into classes; these are subdivided into orders; orders are again divided into genera, and each genus is composed of a number of species. This arrangement is for the purpose of simplifying the study.
COMPOUND EYES.—A number of distinct eyes united into one as in insects.
CONVEX.—A circular or spherical rising as the outside of a globe.
CONCAVE.—Hollow, the opposite of convex.
COCOON.—The web spun by a caterpillar round its body before changing into a chrysalis.

Conferv.e.—A kind of minute plants found in ditches, &c. Mouldiness is produced by a species of this tribe.

Crustaceous.—A term applied to animals having shells or horny cases.

Crescent Shaped.—Like the New Moon.

Diameter.—The measure across.

Digestive.—Pertaining to Digestion or the process to which the food is subjected in the body.

Dissected.—Cut and arranged for the purpose of examination and study.

Dormant.—Concealed, hidden, sleeping.

Ducts.—Channels or vessels.

Elongated.—Longer than broad.

Fahrenheit.—This term is applied to a certain kind of scale on the Thermometer. It is called from the name of its inventor, and is mostly used in England and the United States.

Fibre.—A thread or filament.

Foraminifera.—A kind of Microscopic shells found in chalk &c., which appear perforated with holes of various sizes.

Fossil.—A term applied to the remains of animals and vegetables which have been petrified, or changed into stone.

Genus.—A group enclosing generally a number of species. See Class.

Gelatinous.—Like jelly.

Gills.—The organs by which fishes breathe. They are usually at the side of the head.

Globule.—A little globe.

Guano.—A sort of manure brought from Africa and Peru, which contains abundance of the shells of Animalcules.

Infusoria.—A term applied to Animalcules, because they are usually found in vegetable infusions.

Injecting.—A process by which fine paint or other coloring matter is forced with a syringe into the blood vessels &c., of animals, so as to show the course and arrangement of the vessels.

Integument.—The skin.

Larva.—The first condition of an insect after being hatched from an egg.

Lateral.—Belonging to the side. Sideways.
Lens.—An optical glass through which an object may be viewed. A convex lens is a Microscope or magnifier. A concave lens makes an object appear less.
Lobes.—A term applied to the divisions of an object, particularly if they are roundish in shape.
Lorica.—The shell or shield of an Animalcule.
Lungs.—The organs for breathing in the higher classes of animals.
Marl.—A peculiar sort of earth or clay composed of clay and carbonate of lime.
Mastication.—The act of chewing.
Maturity.—Ripeness, full growth.
Membrane.—A web or expanded tissue; as skin, &c.
Microscope.—An instrument to magnify small objects.
Micrometer.—An instrument to measure small objects.
Monads.—Very small globular or oval animalcules seen by the microscope.
Mucus.—A viscid or slimy liquid secreted in many parts of the body.
Muscle.—A bundle of fleshy fibres; the instrument of bodily motion in a part.
Nodule.—A small lump.
Nutriment.—Food, nourishment.
Oblique.—Slanting.
Oblong.—Longer than broad.
Opaline,—Pearly.
Optical.—Belonging to vision; or to the science of optics.
Organic, Organized.—Having organs or instruments to perform the functions of life; as vegetables or animals.
Oxide.—A chemical substance which is formed by the union of oxygen with some other substance. Iron rust is an oxide of iron.
Parasite.—An animal or plant which lives upon another.
Peat.—Vegetable matter found in bogs in a state of decomposition.
Pedicle.—A footstalk.
Phosphorescence.—A light emitted by many animals and plants, as the firefly, rotten wood, &c.

Polype.—An animal of a peculiar class found in water. They are usually shaped like vegetables.
Polygastric.- Having many stomachs.
Proboscis —A trunk; or elongated organ in front of the head.
Processes.—Protuberances.
Pupa.—The state of an insect after it has changed from the caterpillar or larva state.
Radiated.—Having rays proceeding from it.
Respiratory.—Belonging to the function of breathing.
Resuscitated.—Renewed, raised up again.
Rotatory.—Moving with a circular motion.
Rotifera.—Animalcules with rotatory organs.
Segment.—Part of a circle &c., cut across.
Sensation.—The act of perception by the senses, as seeing, hearing, &c.
Silicia.—Flint, or sand.
Spherical.—Convex, like a globe or sphere.
Spine.—A thorn. The backbone.
Spiral Vessels.—Ducts which are kept on the stretch by a coil of fibre.
Spiracles.—Breathing holes in the sides of insects.
Stratum.—A layer.
Suction Disc.—A roundish, fleshy organ, usually attached to the foot of some animals, by means of which they adhere to the surface of bodies.
Tabular.—Flat.
Trachea.—A breathing tube.
Truncated,—Cut off at the summit.
Tubular.—Like a tube.
Vessels.—Ducts or tubes.
Veins.—Vessels which return blood to the heart.
Vitality.—The principle of life.
Vivacious.—Lively.
Vivification.—The act of giving life.
Whirls.—Branches round a central stem.